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1 514 162

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Patent Application 1 514 162

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Description: Process for manufacturing a semiconductor rectifier cell with surface-to-surface pressure contact

Supplement for: ---

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Applicant: Licentia Patent-Verwaltungs-GmbH, 6000 Frankfurt

Representative: ---

Named as Inventor: Magner, Richard, 4785 Belecke; Herold, Ludwig, 4788 Warstein

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Literature referenced for determining patentability:

DT-AS 1 033 783
DT-AS 1 050 913
DT-AS 1 126 516
DT-AS 1 170 558
US-PS 2 948 050

Mr. Römpp, "Chemistry Lexicon", 4th Edition, Stuttgart 1958, Column 4058 through 4060

Referenced older patents:
German Patent 1 225 772

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The invention concerns a process for manufacturing a semiconductor rectifier cell to the lower part of which a semiconductor wafer that has been emplaced by means of a centering ring makes surface-to-surface contact.

During the manufacture of diffused silicon rectifiers it is particularly difficult to apply to a silicon wafer that is already capable of being processed a silicon coating that adequately shields the pn-junction, whether or not the coating is in the form of paint or silicon rubber. It has been suggested that the silicon wafer first be soldered to the appropriate electrodes using a specified soldering process and then the silicon coating be applied and age-hardened at appropriate temperatures. The result is rectifiers with an excellent shelf life at temperatures of up to 170°C.

It turned out, however, that the voltage characteristics of rectifiers of this type deteriorate during normal operating conditions. Studies have shown that this drop in the reverse voltage quality occurs in conjunction with the applied silicon products combined with soft solders. Presumably, the exposed silicon surface becomes too heavily contaminated during soldering.

If in a reversal of the chronological sequence of the procedural steps the coating is applied first and the soldering done next, the coating must be limited to the edges and the contact surface must remain free from silicon rubber, because soldering can be done only on a surface that is free of silicon rubber. Precise application of the silicon rubber to particular areas of smaller components is so tedious as to be essentially unfeasible.

On the other hand, it turned out that the silicon wafers that are attached to the base plate or the collecting electrode solely by pressure do not display the effect of reduction in reverse voltage quality. However, rectifiers of this type cannot be produced, because at higher voltages flashovers occur easily in unprotected pn-junctions, whereby the rectifier is destroyed. It is not easy to shield the pn-junctions with silicon paint or silicon rubber after components have been pressed together, because exposed silicon material must be heated at temperatures greater than 200°C. Only after this is done are such products suitable for effective protection of the pn-junction.

In prior art based on German Patent Application 1 170 558, in semiconductor rectifier assemblies with pressure contacts the semiconductor wafer is emplaced on the lower part of the housing by means of a centering ring which is made, for example, of a plastic such as polytetrafluorethylene.

Also, in prior art based on German Patent Application 1 126 516, the edges of the semiconductor body of a semiconductor assembly that has been emplaced on the lower part of the housing are imbedded in a synthetic resin that us designed to stabilize the electrical parameters of the semiconductor element.

Additional prior art based on German Patent Application 1 033 783 uses a viscous material that preferably consists of polymethylsiloxanes as the embedding material into which the electrode system is pressed.

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And, finally, from prior art based on US Patent Application 2 948 050 it can be gathered that it is possible during the manufacture of semiconductor assemblies to coat the surface of the semiconductor body that is to be contacted with a dense insulating coating through which a needle electrode which serves as a connection electrode is pressed and then to embed the semiconductor assembly in a viscous layer, for example, one made of silicon grease

A similar process is also recommended in German Patent 1 225 772; according to this process, a wire-shaped counter electrode is pushed onto the semiconductor body through an insulating material and emplaced on the surface of the semiconductor body.

The objective of the invention is to produce sturdy small silicon components and to apply and utilize the advantages of pressure contact technology with surface-to-surface connection electrodes in the manufacture of small components and to thereby avoid the above mentioned problems of reduced stability of components that have been soldered without coatings or of the arduous task of localizing the coating of components that will not be soldered until after the coating is applied.

The invention achieves this objective by a process for [producing a semiconductor rectifier cell with surface-to-surface pressure contact of the semiconductor wafer that is emplaced on a base by means of a centering ring, whereby a drop of a silicon compound is applied to the semiconductor wafer, where it forms a silicon gel when heated, which is then pushed off the contact surface when the semiconductor wafer makes contact with the connecting electrode and which covers the edges of the semiconductor wafer.

It was discovered that when using a silicon compound that in its hardened state has the consistency of a gel, it is possible to heat the exposed compound and to then assemble the rectifier components without any noticeable effect on the passage of current

Silicon materials of this type, for example, have been described in the essay entitled "Silicon Materials Used to Embed and Encase Electronic Components" in "Elektronik", 17th year (1968), Issue 2, pages 33 through 36, specifically section 3.1 "Dielectric Gel".

Even in its hardened state the silicon gel is to a large extent pushed aside by the pressure from the contact surfaces, which does not occur with the various types of silicon paints or silicon rubber, because the consistency of these materials in their hardened states is too tough.

The figures show in partial schematic representation exemplary embodiments of the invention as used with semiconductor rectifier cells.

As shown in figure 1 a rectifier cell has a base 1 that has a small elevation in the center of the floor area.. The diameter of the elevation is somewhat

smaller than that of the semiconductor wafer 2. The diameter is smaller in order to protect the edges of the individual components from breaking when individual components are later pressed together.

A centering ring 3, which fits into an indentation on the base, has the task of holding base 1,

semiconductor wafer 2 and connecting electrode 4 in axial alignment. The connecting or collecting electrode 4 also has a diameter smaller than that of the surface of the silicon wafer. This measure has the same purpose as does the smaller diameter of the elevation on the base.

A spacer plate 5 transmits the pressure produced by a pressure plug 6 to the collecting electrode 4, the semiconductor wafer 2, and the base 1. The actual pressure is produced when the upper part 7 is welded to the base, whereby the pressure plug made of silicon rubber - spring plates can be used instead – presses against the collecting electrode 4 and the semiconductor wafer 2.

The silicon gel 8 is applied around the semiconductor wafer 2 in accordance with the invention.

A copper wire 9 is electro-conductively connected to the collecting electrode 4 that is in the form of a solid head. At the end of the rectifier cell's manufacturing process the copper wire is tightly pressed into a metal sleeve 10 inside the current lead-in the upper part.

Figure 2 shows a similar rectifier cell in which, simply, an additional collecting electrode 12 is located below the semiconductor wafer 2, whereby the pressure plug 6 is simultaneously used as centering ring.

During the manufacture of such a semiconductor rectifier cell, the silicon wafer is initially provided with a conventional metal coating which can be soldered, is cut into appropriate sizes, is etched in a nitric acid-hydrofluoric acid solution at a ratio of approximately 3:1, and is later briefly boiled in an ammonium solution and dried in the open air at approximately 200 to 250°C. The thusly pre-treated silicon wafer is immediately used to produce the rectifier. The silicon wafer is placed into the silicon rubber centering ring 3 and inserted into the base part,

as shown in figure 1. A drop of silicon gel 8 is now added into the upper opening of the silicon rubber ring 3 in accordance with the invention. This part of the assembly is thoroughly heated at 70°C for approximately 24 hours and for approximately 1 to 10 hours dried at 210°C in the open air. Then the silicon rubber plug 6, the spacer plate 5, and the connecting electrode 4 with the copper wire 9 are inserted into the upper part 7. Now, just prior to welding, the top part 7, including the rubber plug 6, spacer plate 5, and connecting electrode 4, is placed onto the base and welded together at point 11.

Rectifier cells produced in this way have withstood storages of more then 1000 hours at temperature between 150 and 170°C, whereby no significant changes occurred with respect to either the attenuation characteristics of the rectifier or its current passing characteristics. These rectifiers also proved to be completely durable in normal operation.

Patent claims:

1. Process for manufacturing a semiconductor rectifier cell to the lower part of which a semiconductor wafer that has been emplaced by means of a centering ring makes surface-to-surface contact, characterized by the fact that a drop of a silicon compound is applied to the semiconductor wafer (2), where it forms a silicon gel (8) when heated, which is pushed off the contact surface when the semiconductor wafer makes contact with the connecting electrode (4) and which covers the edges of the semiconductor wafer.

2. Process according to claim 1, characterized by the fact that the semiconductor wafer that is provided with the silicon compound is thoroughly heated for approximately 24 hours at 70°C and is then dried in the open air for 1 to 10 hours at 210°C.

Attached hereto is one sheet of drawings

DRAWINGS PAGE 1

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Figure 1

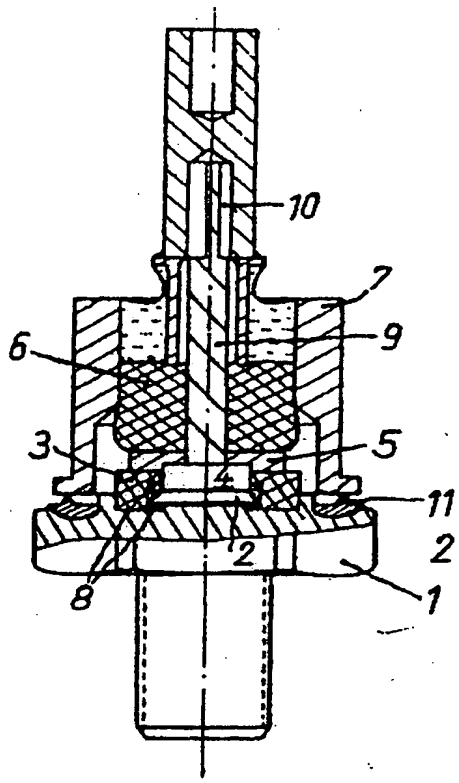

Figure 2